

नायलॉन मोनोफ़िलामेंट्स — विशिष्टि

(पहला पुनरीक्षण)

Nylon Monofilaments — Specification

(First Revision)

ICS 83.140

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Plastics Sectional Committee had been approved by the Petroleum, Coal and Related Products Division Council.

Nylon is extensively used in the manufacture of monofilaments for brushes. Although other materials are also used, yet nylon monofilaments are being increasingly used in place of bristles. Amongst other attributes, nylon monofilaments are easy to wash and have a better abrasion resistance, resilience, and bend recovery. Therefore, they have been found popular for toothbrushes, hairbrushes, nail brushes, and other toilet and industrial brushes.

The diameter of nylon monofilaments is chosen to suit the end use, but the range varies generally from 0.08 mm to 3.00 mm.

Four basic types of nylon (polyamides), namely, nylon 612, 610, 66 and 6 are generally used in the manufacture of nylon monofilaments intended for use as filling material for brushes. Nylon is a linear polycondensation product. Nylon 612 is Poly (hexamethylene dodecanediamide), nylon 610 is poly (hexamethylene sebacamide), nylon 66 is poly (hexamethylene adipamide), and nylon 6 is an internal condensation product hexamethylene diamine (caprolactam). Nylon 6, and to a greater extent, nylon 66 are largely used in the manufacture of nylon monofilaments. Nylon 612 and 610 are, however, not consumed to the same extent, as these are more expensive.

This standard was originally published in 1963. In this revision, the major changes are as follows:

- a) New type of nylon, that is, nylon 612 has been incorporated;
- b) Changes are made in table 1 for incorporating the nylon 612;
- c) Addition of bend recovery has been made in table 1; and
- d) Values of gauge (diameter) has been revised.

The composition of the Committee responsible for the formulation of this standard is given in Annex G.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard
NYLON MONOFILAMENTS — SPECIFICATION
(First Revision)

1 SCOPE

This standard prescribes the requirements and the methods of tests for nylon monofilaments intended for use as filling material for brushes.

2 REFERENCES

The standards given below contain provisions, which through reference in this text constitute the provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most editions of these standards:

<i>IS No.</i>	<i>Title</i>
IS 1070 : 2023	Reagent grade water — Specification (<i>fourth revision</i>)
IS 2828 : 2019/ ISO 472 : 2013	Plastics — Vocabulary (<i>second revision</i>)

3 TERMINOLOGY

3.1 For the purpose of this standard, the definitions

given in IS 2828 shall apply.

4 TYPES

4.1 There shall be four types of nylon monofilaments:

- a) *Type 1* — Manufactured from nylon 612
- b) *Type 2* — Manufactured from nylon 610
- c) *Type 3* — Manufactured from nylon 66
- d) *Type 4* — Manufactured from nylon 6

5 REQUIREMENTS**5.1 Appearance**

The nylon monofilaments shall be cylindrical and smooth. They shall not be wavy or twisted and shall be free from ovalness and indentations.

5.2 Physico-Chemical Requirements

The nylon monofilaments shall comply with the requirements given in Table 1.

Table 1 Physico-Chemical Requirements of Nylon Monofilaments

(Clauses 5.2 and F-2.1.1)

Sl No.	Characteristic	Type 1	Type 2	Type 3	Type 4	Method of Test, Ref to Annex
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Gauge (diameter), in mm	0.08 to 0.60	0.10 to 0.60	0.10 to 3.0	0.10 to 3.0	A
ii)	Melting point, in °C	205 to 215	208 to 218	254 to 259	218 to 223	B
iii)	Density, in g/ml	1.04 to 1.07	1.07 to 1.09	1.13 to 1.15	1.13 to 1.15	C
iv)	Water absorption, percent by weight	1.5 to 2.5	1.5 to 2.5	4.5 to 6.5	4.5 to 6.5	D
v)	Bend recovery, percent, <i>Min</i>	65	65	65	65	E

6 PACKING AND MARKING

6.1 Packing

6.1.1 The nylon monofilaments shall be packed in rolls, hygienically, preferably in transparent packing or colored plastic sleeveings or crepey paper and flexible plastic film wrapping which hold the filaments in a straight form and which are non-toxic and do not attract dirt.

6.1.2 The net weight of each roll shall be approximately 2.0 kg.

6.1.3 The rolls containing nylon monofilaments shall be packaged in lots of 20 kg to 24 kg in cardboard boxes. Each box shall contain rolls of only one gauge.

6.1.4 The length of the monofilaments shall be approximately 1 000 mm to 1 200 mm or depend on the customer requirement.

6.2 Marking

6.2.1 The following information shall be legibly and indelibly marked or stamped on each roll or package:

- a) Material type, gauge, colour and material traceability details;
- b) Manufacturer's name or trade-mark, if any;
- c) The net weight of the material when packed; and
- d) Any other statutory requirements.

6.2.2 BIS Certification Marking

The product(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act, 2016* and the Rules and Regulations framed thereunder, and the products may be marked with the Standard Mark.

7 SAMPLING

7.1 The method of drawing representative sample of the material and the criteria for conformity shall be as prescribed in Annex F.

8 TEST METHODS

8.1 Tests shall be carried out as prescribed in the relevant Annexes to this standard.

8.2 Quality of Reagents

Unless specified otherwise, pure chemicals

(see Note) and distilled water (see IS 1070) shall be used.

NOTE — 'Pure chemicals' shall mean chemicals which do not contain impurities which affect the results of analysis.

8.3 Identification Test

The four types of nylon monofilaments shall be distinguished by the following tests.

8.3.1 Solubility Test

8.3.1.1 Distinguish nylon 612 and 610 from nylon 66 and 6 by their different solubility in hydrochloric acid solution and formic acid of a definite strength.

8.3.1.2 Boil the nylon monofilaments in hydrochloric acid of 4.2 N. Only monofilaments of nylon 612 and 610 will remain undissolved, whereas nylon 66 and 6 dissolve.

8.3.1.3 Heat the nylon monofilament at 60 °C in formic acid. Only monofilaments of nylon 612 will remain undissolved, whereas nylon 610 first deform and swell and then dissolves in 1 min to 3 min (different in time of dissolution depends on the diameter of the monofilament), nylon 66 and 6 dissolves.

8.3.2 Colour Test

8.3.2.1 This is a rapid identification test used for distinguishing monofilaments of nylon 66 from nylon 6.

8.3.2.2 Immerse the nylon monofilaments in a solution prepared by mixing the following:

Phenol	10 g
Lactic acid, 75 percent	10 g
Glycerol	20 g
Water saturated with either cereus blue or cotton blue	22 ml

8.3.2.3 After immersion for 30 s to 45 s, wash free of the coloured solution. nylon 6 monofilaments shall appear deeply colored and considerably swollen.

NOTE — The color test is not applicable to colored filaments in which case the density and melting point values shall be employed for identification.

ANNEX A

[Table 1, Sl No. (i) and F-2.3]

DETERMINATION OF GAUGE (DIAMETER)

A-1 APPARATUS

A suitable calibrated vertical micrometer or dial gauge (± 0.01 mm).

A-2 PROCEDURE

A-2.1 Samples of nylon monofilaments obtained in accordance with **F-2.3** shall be used for determination of gauge.

A-2.2 Mark out three points on each monofilament

at lengths of approximately 30 mm from each other. Take readings with the vertical micrometer or dial gauge at each point but in two positions (obtained by rotating the monofilament through one quarter of its diameter). Note the average, maximum and minimum values.

A-2.3 The average value represents the gauge of the lot from which the sample was taken.

ANNEX B

[Table 1, Sl No. (ii) and F-2.2]

DETERMINATION OF MELTING POINT

B-1 APPARATUS

B-1.1 Thiele Melting Point Tube — with a paraffin bath

B-1.2 Thermometer — conforming to the following requirements:

Range	- 5 °C to + 300 °C
Graduation	1 °C
Immersion, mm	76 mm
Overall length	369 to 393 mm
Stem diameter	6.0 mm to 7.5 mm
Bulb shape	Cylindrical
Bulb length	10 mm to 15 mm
Bulb diameter	5.0 mm to 6.0 mm
Length of graduated portion	222 mm to 262 mm
Distance from bottom of bulb to °C	100 mm to 110 mm
Longer lines at each	5 °C
Figured at each	10 °C
Expansion chamber	Required
Top finish	Ring

Scale error not to exceed	± 0.5 °C up to 150 °C ± 1.0 °C above 150 °C
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NOTES

- 1** Thermometers with the institute of petroleum designation IP 62C conform to these requirements.
2 The thermometer shall bear a certificate from the National Physical Laboratory, New Delhi, or any other institution authorized to issue such a certificate.

B-2 PROCEDURE

Introduce the nylon monofilaments in an ignition tube and fasten it to the thermometer bulb. Gradually raise the temperature of the paraffin bath at the rate of 4 °C to 5 °C per min. Discontinue the heating about 10 °C below the expected melting point. Heat further only if necessary. Near the melting point the nylon monofilaments first shrink and their sides become transparent (the temperature at which the nylon monofilaments melt to a clear liquid).

B-3 DETERMINATION OF MELTING POINT USING DIFFERENTIAL SCANNING CALORIMETER (DSC)

B-3.1 Transition temperatures of polymers (for example, melting point, crystallization, T_g) are majorly measured by industrial laboratories using differential scanning calorimeter (DSC).

NOTE — Refer the standard ASTM D3418-03 for detailed procedure.

ANNEX C

[Table 1, Sl No. (iii) and F-2.1]

DETERMINATION OF DENSITY

C-1 PROCEDURE

C-1.1 Weigh the empty density bottle to the nearest 0.1 mg. Place a suitable quantity of nylon monofilaments (1 g to 5 g) in the density bottle and reweigh to the nearest 0.1 mg. Add enough freshly boiled water to cover the nylon monofilaments. Place the density bottle in the constant temperature bath maintained at a temperature of $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and allow the density bottle and contents to attain the temperature. Fill the density bottle with water at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ to mark and remove it from bath. Carefully wipe and weigh to the nearest 0.1 mg.

C-1.2 Empty and clean the density bottle, fill with freshly boiled water at $27^{\circ}\text{C} \pm 2^{\circ}\text{C}$ to mark, and weigh accurately to the nearest 0.1 mg.

C-1.3 A minimum of two readings shall be taken and their average to be reported as density.

C-2 CALCULATION

C-2.1 The density of the nylon monofilaments shall be calculated as follows:

$$\text{Density of the nylon monofilaments at } 27^{\circ}\text{C, g/ml} = \frac{a}{a + b - c}$$

where

- a = weight of nylon monofilaments in density bottle;
- b = mass, in g, of density bottle filled with water; and
- c = weight of density bottle containing nylon monofilaments and filled with water.

ANNEX D

[Table 1, Sl No. (iv) and F-2.1]

DETERMINATION OF WATER ABSORPTION

D-1 PROCEDURE

Weigh accurately 0.5 g to 1 g of nylon monofilaments in a clean and dry weighing bottle and dry at 105°C to 110°C to constant weight. Transfer this quantity of nylon monofilaments in a 250 ml beaker containing water and keep them immersed for 24 h. At the end of this period, remove the nylon monofilaments, dry them in the folds of a filter paper and weigh.

D-2 REPORTING

Report the water absorbed as a percentage of the

weight of nylon monofilament, taken for the test according to the following:

$$\frac{W_1 - W_2}{W_2} \times 100$$

where

- W_1 mass, in g, of nylon monofilaments after water absorption; and
- W_2 mass, in g, of nylon monofilaments taken for the test after dry.

ANNEX E

[Table 1, Sl No. (v) and F-2.3]

DETERMINATION OF BEND RECOVERY

E-1 APPARATUS

E-1.1 Aluminium or any rust-free metal mold plate with 5 number of holes one each having a diameter equivalent to ten (± 0.5) times of sample filament diameter and the depth of each hole is approximately thirty (± 3) times of sample filament diameter.

Example:

If sample filament diameter is 0.15 mm, the desired hole diameter is 1.4 mm to 1.58 mm and the desired hole depth (or mould thickness) is 4 mm to 5 mm.

E-2 PROCEDURE

E-2.1 Samples of nylon monofilaments obtained in accordance with **F-2.3** shall be used for determination of bend recovery.

E-2.2 Cut the collected monofilament sample as it has a length of 3 to 4 times more than the selected mould thickness/hole depth. Place sample

filament on the mould surface (Refer Fig. 1 for the sample position on the mould surface) so that the midpoint of the filament comes above the mould hole. Push the midpoint of the filament with a soft wooden stick (diameter of stick not more than 50 percent of mould hole diameter) having a curved edges and insert into the mould carefully. Place mould in to a $45\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ water bath for 3 min and then keep it in $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ water bath for another 20 s. Then gently remove sample from the mould. Keep the filament sample in a petri dish filled with $25\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ water for 20 min. Then remove the filament sample from the petri dish and place it on a flat smooth surface and measure the bend angle using protector.

E-3 CALCULATION

Perform the analysis for five different samples and calculate the average bend angle value θ , from which the bend recovery (percentage) can be calculated.

$$\text{Bend Recovery (percentage)} = \frac{\theta}{180} \times 100$$

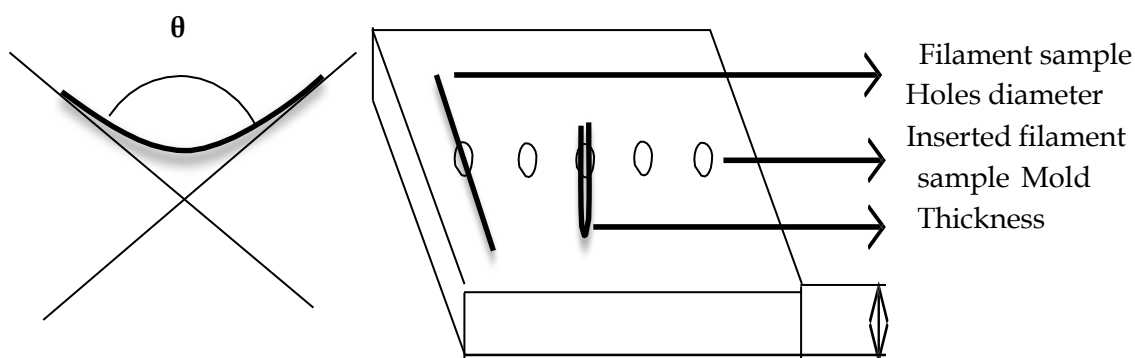


FIG. 1 MOULD SURFACE

ANNEX F

(Clause 7.1)

SAMPLING OF NYLON MONOFILAMENTS AND CRITERIA FOR CONFORMITY

F-1 LOT

F-1.1 In any consignment, all the nylon monofilaments of the same type, gauge and belonging to the same batch of manufacture shall be grouped together into 100 rolls or less and each such group shall constitute a lot.

F-1.2 The conformity of the nylon monofilaments in a lot to the requirements of this specification shall be ascertained for each lot separately. Five rolls shall be selected for this purpose from each of the lots.

F-1.3 The rolls shall be selected at random from the top, middle and bottom portions of the box. If the rolls in a lot are packed in more than one box, approximately equal number of rolls shall be selected at random from as many boxes as possible so as to obtain a total of 5 rolls.

F-2 NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

F-2.1 From each of the rolls selected according to F-1.2, an equal number of strands of nylon monofilaments shall be pulled out with the help of a metal sampler. The strands thus obtained shall be pooled together, for density (Annex C) and water-

absorption determinations (Annex D).

F-2.1.1 The results of density and water-absorption determinations shall satisfy the requirements given in Table 1, before further tests as given in F-2.2 and F-2.3 are carried out.

F-2.2 From each of the remaining portions of the selected rolls, required quantities of strands shall be chosen and shall be separately tested for melting point (Annex B).

F-2.2.1 The lot shall be considered as satisfying the specification requirement for melting point if 4 out of 5 test results obtained according to F-2.2 are found satisfactory.

F-2.3 Four strands of nylon monofilaments shall be picked up at random from each of the remaining portions of the 5 selected rolls so as to obtain a total of 20 strands. These 20 strands of nylon monofilaments shall be measured, for the gauge requirements and bend recovery test (Annex A and E).

F-2.4 The lot shall be declared as conforming to the requirements of the specification, if the stipulations laid down in F-2.1 to F-2.3 are all fulfilled.

ANNEX G

(Foreword)

COMMITTEE COMPOSITION

Plastics Sectional Committee, PCD 12

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Central Institute of Petrochemicals Engineering & Technology (CIPET), Chennai	PROF (DR) SHISHIR SINHA (Chairperson)
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Central Institute of Petrochemicals Engineering & Technology (CIPET), Chennai	DR S. N. YADAV DR SMITA MOHANTY (<i>Alternate</i>)
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Indian Centre for Plastics in the Environment (ICPE), Mumbai	SHRI T. K. BANDOPADHYAY

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